European universities: relationships among age, dimension and science research quality

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Relationships among Age, Dimension and Science Research Quality.*

Preliminary Draft

by
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Abstract

This essay examines the expansion and diversification of the European university system in the post-war period. The impact of an enormous dimensional growth and of the rise in society's expectations for economic returns are analyzed. We develop a multivariate cluster analysis to group the data on the total European university population according to dimension and scientific research quality measures. The age of the university was not used as a clustering variable. Four clusters are found, two of them are composed by clearly distinct group of institutions. The first is mainly composed by new (post-war) universities characterized by: a)small dimensions, b) low research output in terms of scientific publications and participations in EU R&D project, and c) low science research quality and low research intensity. The second comprises almost exclusively pre-war universities (in particular medieval institutions) characterized by: a) large dimension, b) high research output, and, compared to the previous cluster, c) higher science research quality. This clustering seems to support the view of a distinction between a small group of dynamic research oriented universities affected by the current changes in the knowledge production process, and a large group of mainly teaching oriented institutions.

JEL Classifications: I21, I28, H52, L31, O38.

1. Introduction

Until recently, the university has played an unique and essential role in the process of knowledge creation and transmission. As clearly stressed by Perkin (1984, pp.45-46) "A knowledge-based society depends on both the constant advancement of knowledge and the reproduction of knowledgeable people as much as industrial society depends on the constant investment of capital and the reproduction of skilled managers and workers." But if so, does there exist today a place called university where not only the advancement of knowledge through research, and the internal transmission of knowledge through teaching, but also the external transmission of knowledge are realized? To what extent are these goals mutually compatible? Are there changes in societal expectations concerning the kinds of knowledge with respect to which the university should play these dual roles? Are those changes creating tensions that may result in radical transformations of the institution of the university as we know it?

According to Roger L. Geiger (1985, p.53):

"The development of science in the modern era has taken place in a variety of institutional settings. However, since the widespread recognition of German scientific leadership in the last third of the nineteenth century, and continuing through the ascendancy of American science in the mid-twentieth, the university has served as the predominant home of science. Although this nexus between universities and research has been considered virtually axiomatic for a century, it can no longer be regarded as so today. The vast proliferation of modern science has long-since overflowed the confines of the university, while the parallel expansion of higher education has necessitated departures from the university model." [1]

Due to its success both in research and in teaching, the university has grown in dimensional term --*i.e* number of students, number of researchers, financing. In particular, after the Second World War its rapid growth was also connected with a rise in society's expectations for economic returns. These two phenomena, the dimensional growth and the rise of expectations, put the university under strain. Topics such as compatibility between the demands of elite and mass higher education, free research enterprise versus targeted research, private versus public financing, free advancement of the knowledge frontier versus dependence from the need of the society, competition from teaching-oriented and research-oriented institutions have led to counteracting pressures on the institutional organization and roles played by the university.

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[1] A similar view is presented in Gibbons *et al*. (1984).

The historical development of the university testifies to "... its protean capacity to change its shape and function to suit its temporal and sociopolitical environment while retaining enough continuity to deserve its unchanging name" (Perkin, 1984, p.18). Although a large part of the literature concerned with university development has highlighted the present crisis of the university,[2] when we look at its historical capacity of adaptation and at its "...special sort of cultural inheritance with idealistic, spiritual, and high-minded aspiration derived from an important philosophical and theological traditions..." (Rothblatt and Wittrock, 1993, p.1), hope rises again. The recognition of the adaptive ability of the university, highlighted by the historical perspective, enables a better evaluation of its current situation. Instead of being in a phase of loss of importance, the university is going through a period of institutional change. A complex institution like the university tends to resist re-configuration of its structure and institutional organization; thus the result of change is only observable after a long period of time. On the basis of its historical development we can depict the present situation of the university as a phase of transition and redefinition -*i.e.* institutional innovation- of what is however, in Perkin's words, the axial institution of modern society.[3]

The institutional stability, the inertia, of the university historically has led to a slow process of incremental institutional innovation. This process of institutional change can be depicted as a continuous series of adjustments to the changing environment. Unless a profound and disruptive change impelled by shifts in the external socio-political environment of the organization takes place, the roles played, rules followed, and aims to be accomplished can be traced back to the historical development of the institution. Highly diversified modern universities are the result of this process of evolution. The historical and sociological analysis of university development have highlighted a few main features --*e.g.* the independence from external powers of the medieval university, the pursuit of knowledge for its own sake of the nineteenth century university-- that have characterized the university as a peculiar institution throughout its history. Some of these attribute are still present with different degrees of importance in the modern university. Although modern universities have idiosyncratic behaviours and structural specificities they have in common some of the features of an 'ideal type university.' In the following, we shall use the insights from the historical and sociological debate about the definition and role of the university to describe the post-war transition and redefinition of European universities. On the basis of this analysis, we shall study the characteristics of the contemporary population of European universities. Moreover,

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[2] See for example Gibbons *et al.* (1994), Hague (1991) and Scott (1984).

[3] An opposing view is put forward in Gibbons *et al.* (1994), see especially Chapter IV. With the development of what they call *Mode 2* of knowledge production, "...the institutions of higher education, the universities, in particular, will comprise only a part, perhaps only a small part, of the knowledge producing sector. They are no longer in a strong enough position, either scientifically, economically or politically, to determine what shall count as excellence in teaching and research" (Gibbons *et al.*, 1994, p.85). A similar view is put forward in Hague (1991).

we shall develop a multivariate cluster analysis to group, if possible, the data on the total population of European universities according to dimension and scientific research quality measures.

Tab 1: Students by ISCED level of programme

	Level 5	Level 6	Level 7	All Levels
B - 1990	123,970	136,664	15,614	276,248
D - 1990	22,843	120,125	**	142,968
F - 1990	454,055	1,065,600	179,283	1,698,938
G - 1990	220,802	1,578,592	**	1,799,394
Gr -1989	77,159	117,260	-	194,419
I - 1991	10,378	1,474,719	48,105	1,533,202
Ir- 1990	n.a.	n.a.	n.a.	90,296
Nl - 1990 #	252,346	181,795	8,653	442,784
P - 1990	-	182,032	3,730	185,762
S -1989	366	1,143,080	25,695	1,169,141
UK - 1990	383,026	706,089	169,073	1,258,188
TOTAL	1,544,950	6,705,962	450,160	8,791,340

Source: Unesco Statistical Yearbook (1993).
** The figure is included in the figure of Level 6; - Magnitude is either negligible or zero; # It excludes the students of distant learning institutions.

In 1990-1992 the total number of Higher Education Institutions[4] (HEI) in the EU[5] was of *circa* 1429 institutions (IAU 1991, 1993). Looking at the official national classifications, it is possible to subdivide them in 379 Universities and 1050 Post Secondary Institutions[6] (PSI). Nonetheless, when one considers the International Standard Classification for Education (ISCED) the difference between universities and PSI becomes fuzzier (see Table 1 for students subdivision). ISCED level 5 --*i.e.* education at the tertiary level, first stage, of the type that leads to an award not equivalent to a first university degree-- is usually offered by PSI, but sometimes also by universities. ISCED level 6 --*i.e.* education at the tertiary level, first stage, of the type that leads to a first university degree or equivalent-- is normally supplied by both universities and PSI. Finally, ISCED level 7 --*i.e.* education at the

[4] Higher education institutions are institutions that offer education programmes at the tertiary level --*i.e.* programmes classified as either ISCED (International Standard Classification for Education) level 5, 6 or 7. For the definition of tertiary education and ISCED classification see the Glossary of OECD (1995; pp. 366-369).

[5] This count does not include Austria, Finland, Luxembourg, and Sweden.

[6] To calculate the number of PSI we have used an estimate of the PSI in the UK. For the selection criteria of the 379 institutions classified under the class universities see Section 3.

tertiary level, second stage, of the type that leads to a post-graduate university degree or equivalent-- is usually the domain of universities, but sometimes PSI offer Master and Ph.D. degrees. Thus, degree granting specialisations do not seem relevant for justifying a division between universities and PSI.

When knowledge creation and transmission aspects --*i.e.* norms, incentives and organizational structure of the "open science"[7] kind of research-- are put at the core of the analysis, a subdivision is still possible. Nevertheless, as we shall highlight at the end of the second section, the most crucial differences --*e.g.* research orientation, independence in the pursuit of new knowledge, availability of funds-- are the ones between a restricted group of elite research intensive universities and a cluster of universities and PSI, and not the ones between universities and PSI. The official distinction in universities and PSI is, in general, too loose to be relevant for making useful distinctions.

The paper is subdivided into two main parts. In the first we shall discuss the post war development of the European university system (Section 2). In the second part we shall first describe the resulting picture that emerged in the early 1990's, focusing our attention on the population of European universities in 1992. Then, using cluster analysis, we shall group European universities according to dimension and scientific research quality measures (Section 3). Finally, some closing discussion and the concluding remarks will be offered.

2. The expansion and diversification of the European university system

Over the period stretching from the end of the Second World War to the end of the 1970's the university went through a process of rapid growth. The four main driving forces behind this large expansion were the following. First, due to internal logic --*i.e.* the mechanism of subdivision and re-configuration of fields of research into new sub-disciplines and the increased reliance on instrumentation-- the process of scientific inquiry has required an enlarged number of practitioners and a wider financial involvement. Second, the successful use of scientific discoveries made during the Second World War[8] set in a definitive way the 'belief' of a direct applicability of scientific findings. Governments, first in the US

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[7] For an analytical history of the emergence of the institutions of "open science" see David (1994b); for the role played by norms, incentives and organizational structure in the creation of knowledge see Dasgupta & David (1987, 1994).

[8] See especially the Manhattan Project and the Radiation Laboratory at MIT. For a clear analysis of the governmental expectations from science discoveries generated by the war experience see Geiger (1993; Chapters 1,2).

and then in the European countries, regarded scientific research as a source of future welfare, thus directing a large amount of financial resources towards university research. Third, in particular during the 1960's, the shift in demand for level and range of skills by industry and government together with social pressures for democratization of the university system[9] transformed the perception of the educational role of the university. The university was no more considered an elite institution open only to a minority of students usually coming from the higher classes. It became an institution open to all persons qualified by ability to attend it. The opening of new institutions, and the creation of student support schemes tried to implement this new educational role of the university. Fourth, due to the strong economic growth of the post war period, and to the demographic boom, during the 1950's early 1960's, the number of students attending secondary school increased at an extraordinary pace. Consequently, the potential demand for higher education --*i.e.* the number of student finishing secondary school-- expanded proportionally.

Tab 2: Gross Enrolment Ratio. (%)

	B	**D**	**F**	**G**	**Gr**	**I**	**Ir**	**Nl**	**P**	**S**	**UK**
'60	9.1	11.4	7.4	6.1	3.8	6.6	8.1	16.7*	3.5	3.9	9.0
'70	17.5	18.4	19.5	13.4	13.5	16.7	13.6	19.5	8.0	8.9	14.1
'80	26.3	28.6	25.5	26.2	17.4	27.6	20.3	30.0	11.2	24.2	20.1
'90	38.2	35.6	39.7	36.1	25.0	29.8	33.8	37.6	22.7	35.5	27.8

Source: Unesco Statistical Yearbook (1975,1983,1993); * 1965 value.

The expansion of higher education, from *circa* one million students in 1960 to *circa* nine million students in 1990 in the eleven EU countries,[10] brought together a process of institutional diversification (see Table 1 for levels, and Table 2 for the gross enrolment ratio for tertiary education -- *i.e.* total enrolment, regardless of age, divided by the population of the age group 20-24). Mainly under the influence of the respective governments,[11] the enormous increase was absorbed via the enlargement of existing universities, the creation of new universities, and the foundation of new kind of higher education institutions. Following

[9] For the UK case see the report on Higher Education of the Robbins Committee (1963). For an analysis of the Robbins achievement see Scott (1984; Chapter 5).

[10] See note 5.

[11] It is only recently that Europe has developed a number of private higher education institutions. Historically, only a few private religious institutions were active.

the three-fold classification made by Martin A. Trow in 1984,[12] the different kind of higher education institutions can be categorized as: (1) the pre-war universities, (2) the new post-war universities, and (3) the non-university institutions of higher education or, in our words, the post secondary institutions of higher education (PSI).

Although sometimes the second and third kind of institutions are under the same institutional hat, as in the case of the German *Gesamthochschulen* and the comprehensive universities in Sweden,[13] the diversity among the three classes becomes evident when one considers the differences in: (a) research orientation, (b) funding patterns, (c) degree-granting power, (d) organizational forms, (e) teaching and training orientation, and (f) autonomy. In particular, focusing on the degree-granting power and on the research orientation, it is possible to distinguish the universities (pre-war and post-war together) from the PSI. Except for the French *grande écoles* and few other PSI, the university has retained the right of awarding the Ph.D. degree. The university still has a monopoly position in the highest level of education. Although Ph.D. students represent only a small fraction of the total number of students (see Table 1) they are a crucial input both for the education system, as lecturers and researchers in the higher education institutions, and for the knowledge oriented production system, as researchers in public and private research centres. Due to political choice the university, and not the PSI, became the site where the government directed a large amount of financial resources for the development of scientific research.[14] Politics directed the new institutions founded by the national governments primarily to satisfy the educational demand and so, originally, they did not have any research orientation. History mattered, too, in that the pre-war universities were already the place were research was carried out, and thus, due to the accumulated capabilities, they were the most suited place to develop scientific research.

Having said this, is nonetheless important to acknowledge that, during the 1980's and early 1990's, the distinction between universities and PSIs has become fuzzier. Relevant for the understanding of this new trend is what the higher education literature has called the academic drift phenomena. Since their foundation PSIs have tended to emulate universities. The most important reason for this behaviour was that their teaching staff, mainly trained in the university, aimed to gain the rights and privileges of the peers working in the university. This tendency has gained strength after the budget constraints of the late 1970's. A process

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[12] See Trow, M.A., 1984, The analysis of Status, in Burton R. Clark, *Perspectives on Higher Education*, University of California Press, Berkeley.

[13] In France in some cases the *Instituts Universitaires de Technologie* (IUT) are part of pre-existent universities, while in other cases they are independent institutions.

[14] This observation is clearly referring only to the higher education system. After the Second World War the development of scientific and technological research took place not only within the university but also in other public and private sites.

of increased competition for the best professors and teachers, for the most promising students, and for scarce research funds took place. This process found a fertile ground in the diffuse perception of the existence of relevant status differences. The lower status institutions (PSI) developed policies aimed at catching up with institutions of higher status (universities) that had higher funding. The consequence has been a polarization of the system in three main groups. At the top there are almost exclusively the pre-war universities. They have a higher status, more rights and privileges, and wider sources of funds. They are the sites where much of the top scientific research is carried out. A second group is composed by the majority of the new universities and some of the PSI. They are characterized by a lower status and lower funds, but they have right and privileges similar to the pre-war university. They are involved in mainly technical research usually applied and oriented to regional needs. Finally, at the lowest level the group of vocational PSIs that exclusively undertake teaching responsibilities.[15] The national governments opposed resistance to the academic drift because it was undercutting the policy objective of a diversified higher education system containing a large component of vocational and technical education. Nonetheless, as highlighted above, the combination of budget constraints and the push towards a more market oriented approach reinforced the process of academic drift. The response of the government has then been of trying to level the system downward instead of opposing the trend of levelling upward, allowing only for few centres of excellence[16]. Policies of higher control an less autonomy have been developed. The higher education *in toto* has been made more accountable to specific aims of national policy.

An illuminating example of the above described trends is the higher education policy developed in the UK during the 1980's early 1990's. Throughout the 1980's university, polytechnic, and college budget were restructured in ways that put new pressures (and incentives) on the institutions. The actions were undertaken, on the one hand, to stimulate a process of financial restructuring aimed to reduce costs and, on the other hand, to provide incentives, through mechanisms like quality assessment and technology foresight, by which it was hoped that better direction of research effort --*i.e.* more applied oriented-- would result. In 1988, with the Education Reform Act, the role of universities, polytechnic and colleges was suddenly transformed from the one of public institutions subsidized by the state into that of private suppliers of specific services. Finally, in 1993, 39 Polytechnic and Colleges have been granted university status. The old and new university are now all sharing a common

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[15] As one of the main driving forces of this process is the competition for funds, the consequent polarization is more clear in those countries, like the United Kingdom, where the higher education system is more exposed to market forces.

[16] Again, this observation is more true for countries such as the UK where mission oriented policies (selective policies) are applied, while is less relevant for countries like Italy where proportional allocation policies (*finanziamento a pioggia*) are the norm. Still, as the UK system is becoming a potential attraction pole for the other European systems, its current implications are of general relevance.

identity. Thus are all competing for the same research funds and are exposed to a process of selectivity on the basis of assessment of research quality (David, Geuna and Steinmueller; 1995).

Throughout the 1960's and 1970's the EU higher education system has witnessed an impressive growth both in student and researchers numbers, and in financial commitment. Although in some of the less wealthy countries such as Greece, Ireland and Portugal the increase started only in the 1970's, the whole EU higher education system had grown five fold by the end of the period. This transformation from elite to mass higher education has put the university under strain. Part of the expansion has been absorbed by new universities and new institutions, but also the pre-war universities have seen a large increase in their size. The university structure, defined in the nineteenth century on the basis of the medieval guild-like model, was shaped for an elitist system and not for a mass system. In the attempt to satisfy the new demand, the old universities tried to accommodate the growing numbers. Due to the extreme need for teachers, less qualified lecturers found, first temporary, and then tenure positions in the university (Trow, 1984; Simone, 1993). The number of students attending a class increased dramatically, with a consequent decrease of the quality of the instruction. Training oriented courses for new and emerging professions were added to the traditional curricula, creating tensions in the old faculty subdivision. The lost of intellectual preeminence of faculties and departments together with the increase organizational complexity (due to the dimensional growth and to the diversification of goals) opened the way to the bureaucratization of the university. The university was no more a community of peers engaged in the production and transmission of knowledge, but a bureaucratic organization run by officials where scholars were involved in teaching and research together or only in one of the two. The budget constraints and the increased demand for accountability of the 1980's have further weakened the independence and status position of universities.

The trends and forces described in the previous sections have originated a process of change in the structure of knowledge production within the university. First, although most of the prestigious universities of the pre-war period have retained a position of preeminence, their position tends to be limited to particular research fields rather than spanning the knowledge spectrum. Secondly, the lost of intellectual preeminence of faculties and departments has been followed by the rise of the research centre as the intellectual unit of research. This fragmentation has been supported not only by the internal logic of subdivision and re-configuration of research fields, but also by a higher degree of autonomy[17] and lower

[17] The research centre enjoys a higher degree of independence in the setting up of research priorities. Furthermore, due to its flexibility, it can better exploit the external sources of financing. An extremely important advantage in a period of budget cuts.

constraints[18] granted to the centre. Increasingly the university owes its prestige to the research centre, usually associated with a graduate school, and not to particular departments or to the undergraduate teaching. Finally, on the one hand, the process of fragmentation seems to point to a more specialized type of knowledge, while, on the other hand, the knowledge production process at the frontiers of science and technology tends to be more trans-disciplinary in character (Gibbons, 1994).

The reconciliation of the process of fragmentation with the trend towards more trans-disciplinary knowledge production is possible when ones looks at the development of the research network.[19] Due to the increased complexity of the scientific research and to the development of cross-field research, such as in the case of information technologies and molecular biology, scholars sitting in different centres and concerned with fields of research that were traditionally consider separate, interact in the production of new trans-disciplinary knowledge.[20] The rise in cross-countries and cross-disciplines scientific collaboration is connected to the development of large international scientific institutions, such as CERN, and to the increased mobility of researchers. In particular, the mobility of researchers can be realized both in physical terms --*e.g.* through visiting professor schemes, and by use of electronic media --*e.g.* through the development of telecommunication services[21] such as Internet which enable intimate interaction among distant researchers.

After a phase of rapid growth and a following period of budget cuts and policy changes, the higher education institutions, and the universities in particular, are undergoing a phase of transition and redefinition. In the following section we shall analyze what is the resulting picture that emerged in the early 1990's. A clear description of the contemporary population of European universities can, indeed, offer insights for the understanding of the ongoing change.

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[18] Usually the researchers of the centre are less involved in under-graduate teaching.

[19] For a broad approach to the development of the scientific network see Callon (1991).

[20] For the development of international scientific collaboration see Luukkonen (1992). For the development of trans-disciplinary and public-private collaboration see Hicks (1995).

[21] The development of the information and communication technologies and the forecasted fall of the telecommunication costs, down to the level of the simple access cost, can have a crucial impact on the changes that are going on in the higher education system. For example, it is possible to think in terms of interactive video-teaching at zero variable costs.

3. The contemporary university, a cluster analysis

The total university population in the EU[22] was *circa* 379 institutions in 1990-1992. We have classified an institution in the category university following the official national classification. Two other main sources of information have been used: 1) the International Handbook of Universities (1991, 1994), and 2) the World of Learning (1995). When discrepancies between the sources were found, we have classified an institution in the category university if that institution was entitled to grant a doctoral (Ph.D) degree. In a few cases, mainly in Spain and Portugal, we did not take into account the most recent and not yet developed universities. When clearly distinguishable Art, Physical Education, and Education schools were excluded.[23] Finally, the three institutions Universitair Centrum Antwerpen, Universitaire Faculteiten Sint-Ignatius te Antwerpen and Universitaire Instelling Antwerpen have been subsumed under the hat of the University of Antwerp.

Table 3: Count and share of universities, by country

	B	D	F	G	Gr	I	Ir	Nl	P	S	UK	Tot
Univ	15	7	73	75	15	47	7	13	17	39	71	379
%	4.0	1.8	19.3	19.8	4.0	12.4	1.8	3.4	4.5	10.3	18.7	100

In Table 3 we have shown the count and share of universities broken down by EU country. France (73), Germany (75) and United Kingdom (71) together have about three-fifths of all European universities. About one fifth is shared between Italy (47) and Spain (39). Finally, the universities of the six small countries, Belgium, Denmark, Greece, Ireland The Netherlands and Portugal, account for the last fifth of the population.

For each institution, on the top of the geographical information, we have gathered the following data:

NEWOLD: the institution founding year. This has been turned into a categorical variable to classify the institutions in relation to their historical age.
NRES: the number of researchers in 1992.
NSTU: the number of students in 1992.

[22] See note 5.

[23] In most of the countries this schools are not included in the university category. In the few cases in which they have university status, we chose to exclude them.

PART: the number of times the institution has been involved in an EU R&D project. They refer only to shared-cost actions funded by the DG XII under the First, Second and Third Framework Programmes.

PUBS: the number of papers published by a scholar associated to a specific institution in 1993. In the case of one author the count is one, while in the case of co-authorship the count is equal to the number of authors.[24] The data sources is the Science Citation Index, CD--ROM version 1993, published by ISI.

From these row data, two other variables have been constructed. They are:

RESTU: the ratio between the number of researchers and the number of students (NRES/NSTU).

RATIO: the ratio between the number of publications and the number of researchers (PUBS/NRES).

To avoid giving a misleading description a few remarks concerning the kind of data gathered are required here. First, the figure for the number of researchers refers to both teachers and researchers. Due to different ways of classifying university personal in the various EU countries --*i.e.* in Germany and The Netherlands the teachers' group accounts also for short term lecturers and student assistants-- the Germanic countries tend to have a positive bias in the NRES variable. Second, the variable PUBS has been built only on the basis of the Science Citation Index, the Social Science SCI, that refers to humanities and social sciences, has not been used. The variable PUBS is, thus, relevant for medical, natural and engineering sciences and not for the other fields of knowledge present in universities. Therefore, institutions with a clear focus on humanities and social sciences have a very low number of publications. Third, the variable PART counts the participations in scientific R&D projects. Thus, institutions with a clear focus on humanities and social sciences are badly represented in it. Finally, the variables NEWOLD, PUBS and PART are arguably poor measures for the French university system. In 1970 a large number of French universities were subdivided into two or more different institutions. We have found it difficult to assign an exact founding year to these institutions. In listings all of them report the founding date of the predecessor, although, at the same time, new institutions were established. Still, we preferred the old founding year, pushing up in an artificial way the share of old universities.[25]

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[24] For the analysis of all the problems connected with data collection see EC (1994) pp.38-40. Special mention must be made of the peculiar role played by hospitals. Their weight in the presence count is not just over-estimated because of the effect of co-authorship, it is also often unclear whether they are linked to the university or not. Then, in some cases the publication is counted as university and other as hospital. This varies among the European Countries due to widespread institutional variety.

[25] In 1992, the 65.8% of the French universities has been established before the French revolution. This is the highest figure for the European countries.

In the process of gathering the publication data, due to the fact that for French authors the faculty affiliation was before the university name, we have been unable to classify under a specific institution a number of publications larger than in other countries. The variable PUBS is, thus, biased downward for some of the French institutions. Due to the fact that a large share of scientific research is realized outside the university system,[26] and to the administrative and bureaucratic structure of the French university system, the French institutions were also involved in a low number of EU R&D projects (Geuna, 1995).

In short, due to the bias present in the variables PUBS and PART, the observations concerning institutions' output and scientific research quality presented in the following analysis will not be relevant for institutions with an important involvement in humanities and social sciences. The conclusions developed in this paper, based on output and scientific research quality measurements, are only pertinent for natural, medicine and engineering sciences.

Table 4: Frequency distribution by historical classes

Historical Class	Frequency	Percent
1	144	38.0
2	32	8.4
3	77	20.3
4	126	33.2
	379	100.0

Looking at the historical development of European universities four broad phases can be found.[27] In relation to the founding year of the university, we subdivided the total university population into four historical classes. They are: (1) the new post-war universities [>1945]; (2) the early twentieth century universities, that have been founded over the period stretching from the starting of the twentieth century to the end of the Second World War [1900-1945]; (3) the nineteenth century universities, that have been founded in the period of the so called German transformation after the founding of the university of Berlin in 1809 by Wilhelm von Humboldt [1800-1899]; and (4) the old universities, that have been founded before the French revolution [<1800]. Table 4 illustrates the universities frequency distribution by historical classes. The largest class, with 38.0% of the universities, is the one

[26] The CNRS is the principal site where publicly funded scientific research is carried out. Moreover, engineering sciences are primarily studied at the *grande écoles*, that are institutions not included in the class university.

[27] More detailed sub-divisions, considering also the history of non-European universities, can be found in the historical literature. See for example Perkin (1984) and Wittrock (1993).

of the new institutions. *Circa* two-fifth of the active universities have been founded in the last 50 years.

In table 5 we present the descriptive statistics for the six other variables. All the variables shows a high Kurtosis and a positive Skewness (in particular in the case of RESTU and RATIO) that indicates concentration in the values.[28] Taking also into account the high standard deviations and the large differences between Min and Max, we can describe the population of universities as composed by a large number of small-medium size institutions and some very large institution. Moreover, as the variable RESTU can be interpreted as the propensity of the institution to carry out research --*i.e.* research orientation, its high skewness points to the fact that a large number of universities have a low research orientation. Finally, as the variable RATIO can be used as a proxy for the research quality of the institution,[29] the population of universities is characterized by a large group of institutions with a low research quality, and by a small group of institutions of high research quality.

On the basis of these observations and of the reflections put forward in section two --*i.e.* the polarization of the higher education system, we decided to use cluster analysis to group the data of the total university population in clusters that have small within variation and high between variation. When clusters with different characteristics (the variables clustered have different means in the various group) are found, their analysis may support the observations and reflections above made.

Table 5: Descriptive statistics for the main variables

Variable	Valid Cases*	Mean	Std dev	Min	Max
NRES	371	886.833	945.784	15	7330
NSTU	371	15375.544	17627.945	100	166301
PART	371	49.032	64.809	0	420
PUBS	371	414.919	519.277	5**	3185
RESTU	371	0.078	0.074	0.010	0.652
RATIO	371	0.568	0.971	0.005	12.340

* Eight cases have been excluded due to missing data. ** Estimate value.

[28] Moreover, the variables are correlated as noted below.

[29] The sociology of science, and more recently, empirical studies in the New Economics of Science have made use of bibliometric analysis. In particular, the idea behind paper or citation counts is that they can be used as an indicator of the underlying "quality" of the researcher. Consequently is possible to depict the research "quality" of the university as the ratio between the publications realized in one year and the number of researchers attached to that institution (Geuna, 1995).

Due to high correlation among the six variables used for our analysis (NEWOLD is excluded at this stage of the analysis), we first combine them in principal components. Table 6 illustrates the Eigenvalues and the percentage of total variance explained by each principal components. We choose to work with the first three principal components, all of them have a Eigenvalue higher then 1, and 82.1% of the total variance is attributable to them. To construct the three new variables on which we run the cluster analysis, we use the principal component loadings shown in Table 7, they are the Eigenvectors associated with the eigenvalues after a Varimax rotation.[30]

Table 6: Eigenvalues

Variable	Princ Component	Eigenvalue	Pct of Var	Cum Pct
NRES	1	2.54883	42.5	42.5
NSTU	2	1.32907	22.2	64.6
PUBS	3	1.04758	17.5	82.1
RATIO	4	0.63088	10.5	92.6
RESTU	5	0.25512	4.3	96.9
PART	6	0.18853	3.1	100.0

Table 7: Rotated loading matrix

Variables	Princ. Component 1	Princ. Component 2	Princ. Component 3
NRES	0.90903	-0.00894	0.24568
NSTU	0.85033	-0.00832	-0.27436
PUBS	0.66416	0.64028	-0.01062
RATIO	-0.21552	0.85673	0.11344
RESTU	-0.00766	0.05094	0.98412
PART	0.48950	0.61628	-0.07248

When we look at the loadings of the first principal component, NRES and NSTU have the higher loadings (also PUBS and PART have important loadings), thus, the new variable represents the combined dimensions of the institution. It is a proxy for the size of the institution. The second principal component combines PUBS, PART and RATIO, thus it can be interpreted as an index of the science research output, both in terms of quantity and

[30] The Varimax method attempts to minimize the number of variables that have high loading on a factor. This orthogonal rotation does not effect the goodness of fit of a factor solution, the total variance explained do not change.

quality. Finally, the only important loading of the third principal component is RESTU. Therefore, the new variable depicts the research orientation of the institution.

To investigate the possible clusters within the three new variables (PRIFIN1, PRIFIN2, PRIFIN3) we used a hierarchical cluster analysis. Ward's method, that combines clusters with the smallest increase in the overall sum of the squared within-cluster distances, has been chosen due to its propensity of joining clusters with a small number of observations. Characteristics of the hierarchical cluster analysis is that the number of clusters is not fixed. To determine the number of clusters that we shall analyze we performed a Scheffé test with a significance level of 0.05. For each variable used, the test makes a comparison of the means of the various clusters. The best solution is given by the grouping into four clusters. The clusters are well separated in the variables PRIFIN1 and PRIFIN2, and less clearly in the variable PRIFIN3 (see Appendix 1). Due to the peculiarities of the French data, we have repeated the analysis with a database that did not included France and comparable results were found. In the following analysis of the four clusters we will present the results for the case of the total university population (TUP), and sometimes also for the case of the exclusion of France (EF).

Table 8: Cluster composition, count and share of universities

Clusters	Total University Population		Exclusion of France	
	Frequency	Percent	Frequency	Percent
1	192	51.8	168	56.2
2	107	28.8	56	18.7
3	8	2.2	7	2.3
4	64	17.3	68	22.7
Total	371	100.0	299	100.0

Table 8 shows the number and share of universities in each cluster. The exclusion of France causes the movement of 8 universities from the second to the fourth cluster and 1 in the other way. While, 33 universities transfer from the second to the first cluster and 1 from the third to the first.

What are the characteristics of the clusters?. First, we are interested in studying the historical composition of the clusters. Tables 9a illustrates the frequency chart for the four historical classes defined above for the case of the total university population and Table 9b for the case of the exclusion of France. Cluster 1 contains a majority of post-war universities of whom 73.5% are in this cluster. Cluster 4 is composed by a majority of medieval universities and only 7.8% of the institutions of this cluster are post-war universities. When

we look at the EF case the first cluster becomes more polarized towards the new universities, this is consistent with the bias in the historical classification of French universities. If we think in terms of pre-war, post-war universities we can define the cluster 4 as the cluster of the pre-war universities, while for cluster 1 we can only speak of stronger polarization towards the post-war universities.

Table 10: Cluster composition, mean values for the six variables

Mean Value	Cluster 1	Cluster 2	Cluster 4
NRES	454.323	781.944	2115.547
NSTU	9363.740	13531.879	38304.188
PART	12.594	71.776	124.656
PUBS	81.484	559.907	1173.688
RESTU	0.066	0.069	0.091
RATIO	0.198	0.912	0.617

Second, dimension, scientific research quality and research orientation of the universities in the four clusters are analyzed (see table 10). The first cluster is composed by institutions with a mean of 454.323 researchers and a mean of 9363.740 students. They have participated in a mean of 12.594 EU R&D project, and they have published a mean of 81.484 publications. The research orientation, expressed in number of researchers per students, has a mean value of 0.066. The mean research quality of the institution in terms of publications per researcher is 0.198. Comparing these value with the ones of the total population we can highlight that the universities of the first cluster tend to be of small dimension, they have a low output in terms of publications and participation in EU R&D projects, and they have lower research quality and research orientation. The member of the fourth cluster are large universities (mean NRES of 2115.547 and mean NSTU of 38304.188), they had a large number of participations in EU R&D projects (mean PART of 124.656) and they tend to publish a lot (mean PUBS of 1173,688). Research quality and research orientation tend to be higher than the ones of the total population, but not in an extremely important way (mean RESTU of 0.091 and mean RATIO of 0.617). Cluster number two is characterized by institutions with a mean number of researchers and students slightly smaller than the total population (781,944 and 13531,879) and a mean number of participations and publications higher than the total (71.776 and 559.907). The research orientation is a bit lower then the average (0.069), while the research quality of the institutions tend to be higher of the one of the total population, and the highest of the four clusters (0.912). Of particular interest not for the statistics, but for the institutions included is cluster 3. Five of the eight institutions are London University Medical Schools. Due to way the publications are gathered (see note 28) these schools are characterized by an extremely high number of publications, and they have

extremely high values in both RESTU and RATIO. The existence of a cluster of this type testifies to the discriminatory power of the statistical methods used. The same kind of analysis has been carried out for the EF case. The movement of institutions among clusters above-mentioned tends to slightly increase the mean values of output, research quality and research intensity for cluster 1, and pushes all the value of cluster 2 a bit above the average of the total population. A possible interpretation is that the exclusion of the French universities[31] tends to attract in cluster 1 the institutions on the left side of the distribution of cluster 2. Consequently some of the institution on the right side of the distribution of cluster 2 are attracted in cluster 4.

Table 11 in Appendix 1 presents the same kind of analysis in terms of frequency chart. The variables NRES, PUBS, PART, RESTU and RATIO have been transformed into categorical variables at the quartile. In this way we have built five indexes, one of dimension, two of research output, one of research intensity, and one of scientific research quality. The association of these indexes with the clusters formed enables us to confirm the previous observations. The institutions in cluster 1 tend to have low and medium-low dimension, research output and research quality. Cluster 4 is mainly composed by institutions of large dimension, high number of publications, and high number of participations in EU R&D projects.

The analysis of the university population in the early 1990's points to the existence of two clearly distinct clusters of institutions. The first is mainly composed by new (post-war) universities characterized by: a) small dimensions, b) low research output in terms of scientific publications and participations in EU R&D project, and c) low scientific research quality and low research intensity. The second comprises almost exclusively pre-war universities (in particular medieval institutions) characterized by: a) large dimension, b) high research output, and, compared to the previous cluster, c) higher scientific research quality. In the following conclusive remarks, we shall connect these results to the historical analysis of Section two and we shall try to put forward some tentative interpretation.

3. Conclusions

The picture of the European university population drawn in the previous section tends to confirm the view that after a period of rapid growth and a period of budget cuts and policy changes, a portion of the prestigious pre-war universities have managed to retain a position

[31] Due to data gathering problems the French university tend to be large, but with low output, low research quality and low research intensity. Thus, the high number of French universities in cluster one biases the mean values of the cluster.

of preeminence. Whereas, the large majority of the new post-war universities did not succeed in increasing their status. Although some of them tried to upgrade their status, also due to the impact of cumulative and self-reinforcement phenomena, they usually did not succeed in it. One of the reasons for their failure can be found in the so called Matthew effect.[32] A good researcher is usually attracted by centres/universities of excellence where she can find the human and physical capital that enables her to develop high level research. Doing that she will improve her quality and the overall quality of the institution, with the consequence of attracting new research funds and new high value researchers. This situation is characterized by two interrelated virtuous circles. First, a centre of excellence attracts high quality researchers that have high probability of doing valuable research increasing then the quality of the centre and therefore attracting new talented researchers. Second, a high level of human and physical capital implies a higher chance of achieving important research results, hence as a consequence of the high quality research there is an increased probability of having new research funds and therefore a possibility of expansion in the investment in human and physical capital.

The changes in the knowledge production emphasized at the end of section two --*i.e.* 1) the old universities are no longer spanning the knowledge spectrum, 2) the rise of the research centre as the intellectual unit of research, and 3) the development of the research network-- are more likely in the pre-war institutions highly involved in scientific research -- *i.e.* those in cluster four. These research universities, usually elite pre-war institutions and a handful of new institutions, will shape and will be reshaped by the new structure of knowledge production. The institutions in cluster one, either involved in technological research or only teaching institutions, are only witnesses of this process. Less clear is the position of the universities of the second cluster. For them, probably, the change in the knowledge production will be a strong challenge that can upgrade their status or downgrade them toward cluster one.

Whatever the reasons, the outcome of the forces and trends we have described is a clear cut division between a small group of dynamic research oriented universities and a large group of mainly teaching oriented institutions. Without entering in a discussion on the value of this outcome, is nonetheless crucial to highlight the risk of a possible separation of teaching, mainly under-graduate, from research, one of the founding principle of the university. The national university developed in the nineteenth century composed by a community of mainly national peers, covering a broad spectrum of disciplines, and focused

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[32] For an economic analysis of the so-called "Matthew effect" and its implications for resource allocation see Arora, David and Gambardella (1994), Dasgupta & David (1987, 1994), David (1994a) and Geuna (1995). For its implications on the university status see Trow (1984). For its original definition in the sociology of science see Merton (1968)

on both teaching and research tends to disappear. A new kind of institution, in its international character and in its disciplinary specialization more similar to the old medieval university, is starting to develop.

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Table 9a: Cluster composition, by historical classes. TUP

Historical Cl.	Cluster 1			Cluster 2			Cluster 3			Cluster 4		
	Count	Row %	Col %	Cont	Row %	Col %	Count	Row %	Col %	Count	Row %	Col %
>1945	100	73.5	52.1	30	22.1	28.0	1	0.7	12.5	5	3.7	7.8
1990-1945	13	40.6	6.8	9	28.1	8.4	2	6.3	25.0	8	25.0	12.5
1800-1899	28	36.4	14.6	37	48.1	34.6	2	2.6	25.0	10	13.0	15.6
<1800	51	40.5	26.6	31	24.6	29.0	3	2.4	37.5	41	32.5	64.1

Table 9b: Cluster composition, by historical classes. EF

Historical Cl.	Cluster 1			Cluster 2			Cluster 3			Cluster 4		
	Count	Row %	Col %	Cont	Row %	Col %	Count	Row %	Col %	Count	Row %	Col %
>1945	99	83.9	58.9	13	11.0	23.2	0	0	0	5	4.3	7.4
1990-1945	16	50.0	9.5	7	21.9	12.5	2	6.3	28.6	7	21.9	10.3
1800-1899	33	45.8	19.6	21	29.2	27.5	2	2.8	28.6	16	22.2	23.5
<1800	20	25.6	11.9	15	19.2	26.8	3	3.8	42.9	40	51.3	58.8